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1	WHC-SD-EN-ER-002		0	Geophysical Survey of White Bluffs Cribs Site	4	2		

16. KEY

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7. Abstract

WHC, 1992, *Geophysical Survey of White Bluffs Cribs Site*, WHC-SD-EN-ER-002, Rev. 0, prepared by IT Corporation, Irvine, California, for Westinghouse Hanford Company, Richland, Washington.

9. Impact Level 4

10. RELEASE STAMP

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Table of Contents

List of Figures

1.0 Introduction

A geophysical survey was conducted at the White Bluffs Cribs site in Hanford, Washington, from September 14 through 19, 1992. Figure 1 presents the approximate site location with respect to the Hanford Nuclear Reservation. The investigation was conducted approximately ½ mile southwest of Route 2 and 600 feet south of Federal Avenue, as shown in Figure 2.

The purpose of the geophysical investigation was to (1) determine the location of subsurface pipes leading to two gravel cribs (leach fields) used to distribute acids from a former metal pipe pickling acid facility, and (2) characterize the acid distribution pipe network within the cribs. To identify the locations of the subsurface pipes leading to the cribs, five ground-penetrating radar (GPR) profiles, totaling about 425 line feet, were acquired north of the site. A utility/pipe locator was then used to map the pipes beyond the northernmost profile. The acid distribution pipe network within the cribs was characterized by conducting electromagnetic induction and GPR surveys, each totaling about 12,400 line feet, in an approximately 1.4-acre area encompassing the cribs.

Field procedures used during the geophysical investigation are described in Section 2.0, the data processing methods used and interpretations of the geophysical data are presented in section 3.0, and conclusions derived from the geophysical surveys are presented in Section 4.0.

2.0 Field Procedures

This section describes the field procedures used during the electromagnetic induction and GPR surveys. Electromagnetic induction equipment consisted of a Metrotech Model 810 utility/pipe locator and a Geonics EM-31DL terrain conductivity meter (EM-31) coupled to an Omnidata digital data logger. GPR equipment consisted of a Geophysical Survey Systems Inc. (GSSI) System 10 unit coupled to a 500-megahertz (MHz) antenna. A description of the equipment and a theoretical discussion of the geophysical methods are presented in Appendix A.

The geophysical survey area was determined in the field by examining surface characteristics of the gravel cribs and the location of some pipes exposed near the surface and oriented north, away from the cribs. The survey was conducted in a 170- by 350-foot area (Figure 3), in which a base grid was marked with surveyor's paint to provide spatial control during the investigation. A base grid line spacing of 10 feet was selected based on site characteristics and the degree of resolution required for the survey. Control points were marked at 10-foot increments along the survey lines. Large pieces of metallic surface debris were removed from the site prior to conducting the geophysical survey in order to limit the effect of such objects on the data. The ends of all north-south-oriented lines were staked with survey lath and labeled so that anomalies could be field checked and accurately mapped following completion of the survey.

Before the start of the EM-31 survey, a base station was established approximately 100 feet west of the site in an area unaffected by buried debris or cultural interference (e.g., fences, power lines, or metallic objects present as a result of human activity). Before any data were acquired, the instrument was calibrated and the in-phase component was zeroed at the base station used to monitor instrument drift. After the instrument was calibrated, conductivity and in-phase component readings were collected at the base station and stored in a digital data logger.

After initial base station readings were completed, conductivity and in-phase component field strength measurements were made with the EM-31 at 5-foot intervals along perpendicular survey grid lines. The EM-31 data were stored in the digital data logger programmed with appropriate line and station numbers. After EM-31 data were acquired, additional readings of conductivity and in-phase component were made at the base station to evaluate instrument drift during the survey period. All EM-31 data were then downloaded to a laptop computer and previewed in the field to assure data quality.

The GPR data were recorded semicontinuously (50 scans per second) as the 500-MHz antenna was hand towed over the perpendicular survey grid lines. During data acquisition, survey line control points were marked at 5-foot incrments on the GPR records using a marker switch located on the antenna unit. The control points were marked at 5-foot increments so that GPR anomalies could be accurately mapped in the field following the investigation. Digital data were field previewed in real time on a color monitor and stored on digital tape for later processing.

Surface metallic objects and other significant surface features were field mapped to help differentiate EM-31 and GPR anomalies caused by surface sources from those caused by subsurface sources. Preliminary color contour maps of the EM-31 data were developed and field checked immediately following the survey. Color profiles of the GPR data were generated daily as the survey progressed. Geophysical anomalies caused by pipes and other site features were field checked to verify their source. During the field verification phase, EM-31 and GPR anomalies caused by the pipes leading to the acid cribs were carefully delineated using the Metrotech pipe/utility locator. The pipes were traced by placing the Metrotech transmitter on the ground surface above the pipe, locating the pipe using the receiver, and marking the direction of the pipe with surveyor's paint and labeled wooden stakes.

3.0 Data Processing and Interpretation

This section describes the data processing procedures used and results of the site geophysical investigation, as interpreted from the data acquired.

3.1 Data Processing

Color-enhanced contour maps of EM-31 data were generated using the GEOSOFT® geophysical mapping system. These maps were color-enhanced to facilitate recognition and interpretation of subtle anomalies. Prior to map generation, a number of preprocessing steps were required.

The DAT31 software program by Geonics Ltd. was applied to EM-31 data to generate XYZ files for input to the GEOSOFT contouring program. The XYZ files were merged and optionally sorted using in-house software. Edited XYZ data files were then entered into the GEOSOFT program, where the data were gridded, optionally filtered, or otherwise processed and color-contoured. The names of the files generated and processing parameters used were recorded on a data processing form.

Digital GPR data acquired using the GSSI System 10 were processed using the computer program RADAN 3®, written by Geophysical Survey Systems, Inc. Data were first downloaded from 8-millimeter (mm) digital tape to an external hard disk. The data were horizontally stacked both to increase the signal-to-noise ratio and to reduce the record length. Gain control and selected horizontal and/or vertical filters were applied to the data where necessary to enhance features of interest. Color-enhanced GPR records were printed on a Hewlett Packard paintjet printer.

3.2 Interpretation

Color-enhanced contour maps of conductivity component data collected with the EM-31 along south-north and west-east survey lines are presented in Figures 4 and 5, respectively. Interpretation of all site geophysical data is shown in Figure 3. Selected GPR profiles representing the geophysical survey area and the area north of the site are presented in Figures 6 through 13.

Several anomalies are evident on the contour maps of EM-31 data. Two anomalies caused by pipes leading from the former metal acid pickling facility to the two acid cribs are identified as P-1 and P-2 in Figures 4 and 5. Anomaly A-1, located near the western boundary of the survey area, is caused by the variation in subsurface conductivity between the west gravel crib and natural sediments to the west. North-trending anomaly A-2, found in the central portion of the west crib, is caused by the main distribution pipe within the crib. Anomaly A-3, located in the north part of the west crib (Figure 4), is a result of an increased EM response of the instrument to the pipe as the pipe leading into the crib passes through a subsurface depression. Anomaly A-4, which occurs in the southeast portion of the survey area, is interpreted as a naturally occurring subtle change in near-surface soil characteristics detected while approaching an area field mapped as a natural depression. The EM-31 response is probably due to a slight local decrease in soil grain size and/or increase in moisture content.

GPR anomalies present in the record of line GPR-50E through the west crib are caused by 25 west-trending lateral pipes (Figure 7). The pipes are equally spaced at 7-foot intervals throughout the crib, starting approximately at position 48 feet. What is interpreted to be the main acid distribution pipe, running lengthwise through the west crib (Figure 7), occurs as a weak reflector between approximately 13 and 15 nanoseconds (ns). Also evident is the interface between the crib and native underlying soil. This strong reflector representing the base of the crib occurs at a depth of about 7 feet (42 ns). A depth conversion factor was calculated for all GPR profiles (Figures 6 through 13) based on an average two-way travel time velocity of 6 nanoseconds per foot (ns/ft). This velocity represents soil conditions encountered at the site.

West-to-east GPR profiles recorded at locations 140N and 200N (Figure 11) indicate that the previously discussed north-trending distribution pipe within the west crib occurs at an approximate position of 52 feet. Three north-trending pipes are evidenced in the east crib, as shown in Figure 11 at positions of 90, 104, and 119 feet. The visible difference between the two cribs on the records shown in Figure 11 results from the GPR instrument response to the different crib designs. Surface observation of the cribs indicated that the west crib is constructed of approximately 3-inch-diameter cobbles, whereas the east crib is constructed of approximately 5-inch-diameter cobbles.

Anomalies caused by pipes leading to the acid cribs from the former metal acid pickling facility north of the site are visible in the GPR records from lines 405N and 465N (Figure 13). The pipes are observed to converge toward a point approximately 110 feet north of the survey area (Figure 3).

During field verification, anomalies caused by the pipes leading to the acid cribs were successfully traced from within the main survey to beyond the northernmost GPR profile using the pipe/utility locator (Figure 3). The pipe locations were marked with surveyor's paint on the ground and labeled with wooden stakes in several locations to indicate line direction.

4.0 Conclusions

Geophysical surveys using electromagnetic induction and GPR methods were conducted at the White Bluffs Cribs site to characterize the acid distribution pipe network within the cribs and to determine the location of pipes leading to the cribs from the former metal acid pickling facility located north of the site.

A site map showing interpretations of the geophysical data is presented in Figure 3. The EM-31 survey sucessfully delineated two pipes in the northern portion of the survey area, leading south to the acid cribs, as shown in Figures 4 and 5. The GPR survey successfully determined the location of 25 west-trending lateral pipes evenly spaced throughout the west crib at 7-foot increments, beginning approximately at position 48 feet. A centrally located main distribution pipe (approximately at position 52 feet) running the length of the crib (Figures 10 and 11) was also interpreted from the GPR records of the west crib. In the east crib, three north-trending pipes were successfully mapped on GPR records from lines 140N, 200N, and 260N (Figures 11 and 12).

The locations of the pipes leading south to the cribs from the former acid pickling facility (as observed from EM-31 and GPR data) were successfully traced with the pipe/utility locator in the area north of the site (Figure 3). The locations of the pipes were staked and painted on the ground in several locations for future reference.

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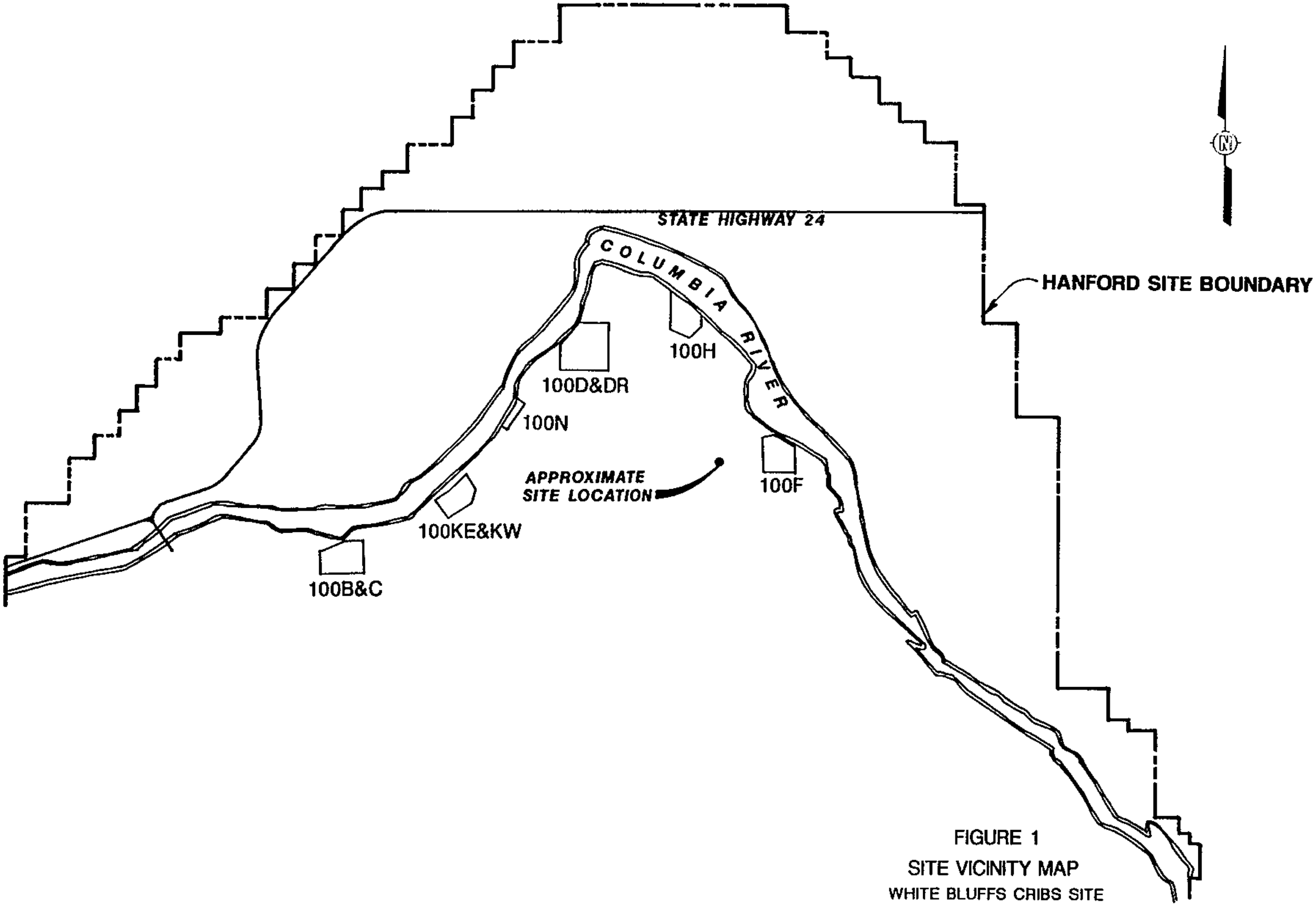

FIGURE 1
SITE VICINITY MAP
WHITE BLUFFS CRIBS SITE
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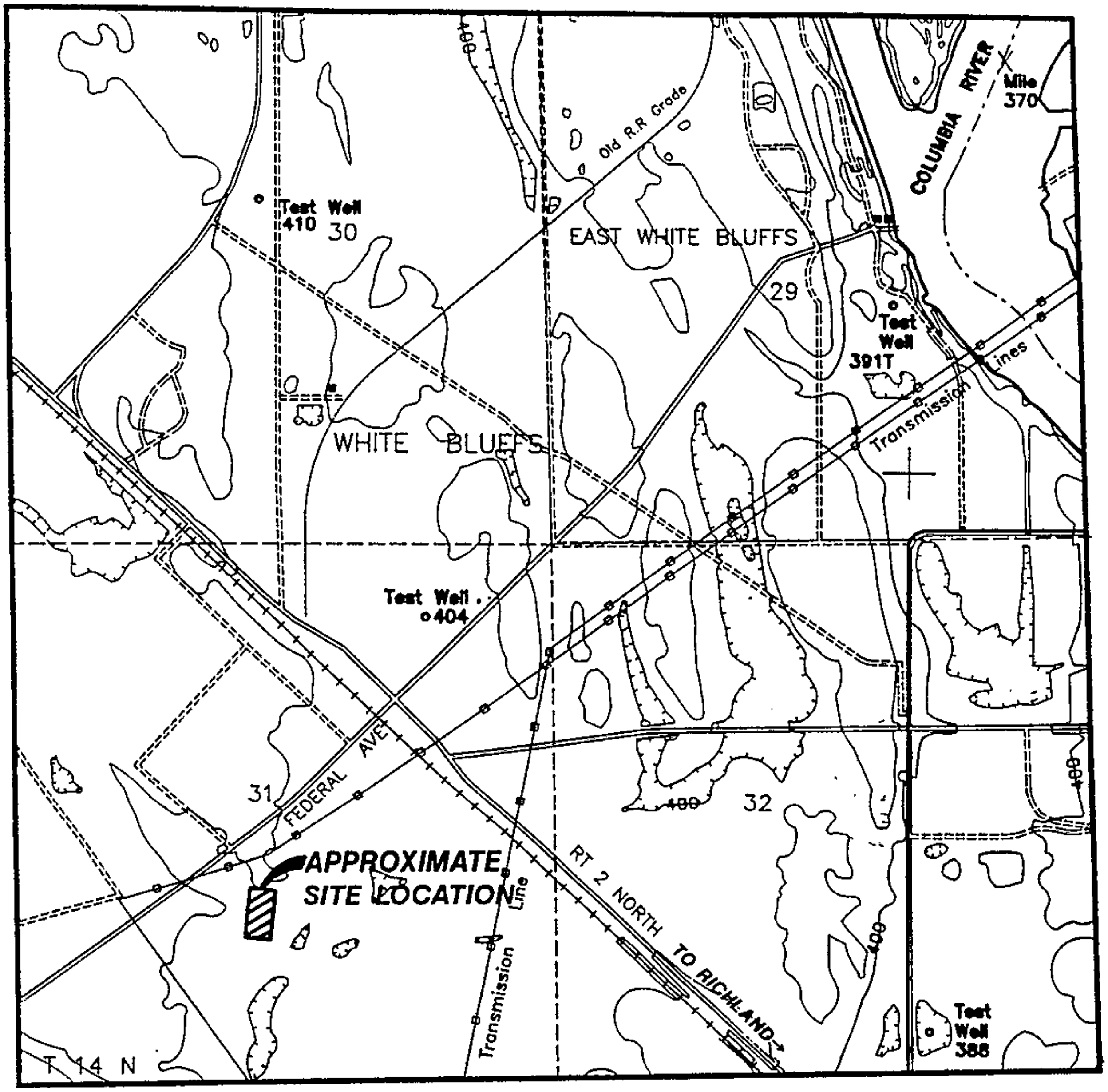

FIGURE 2

SITE LOCATION MAP

WHITE BLUFFS CRIBS SITE

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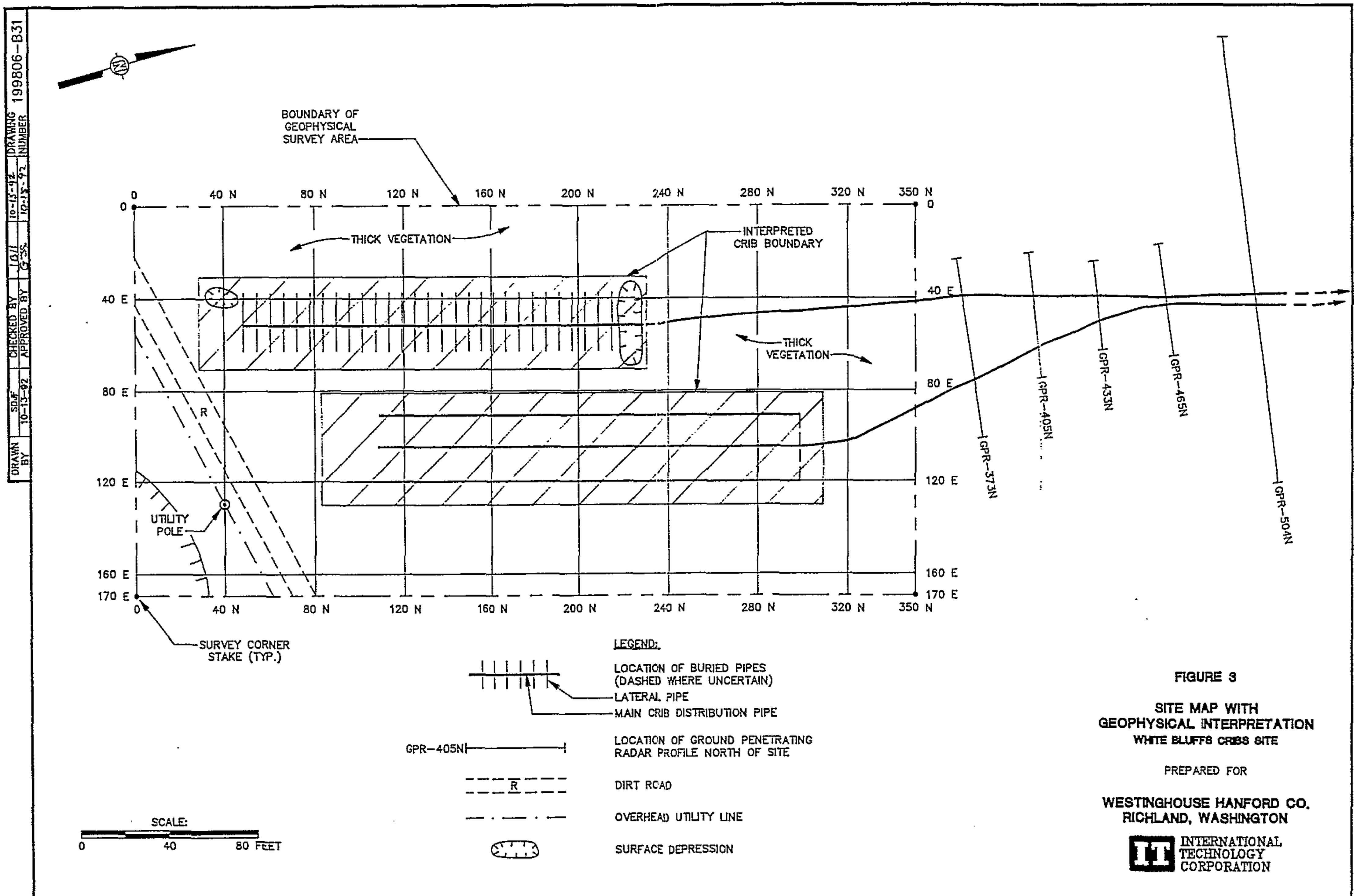

FIGURE 3

SITE MAP WITH GEOPHYSICAL INTERPRETATION
WHITE BLUFFS CRIBS SITE

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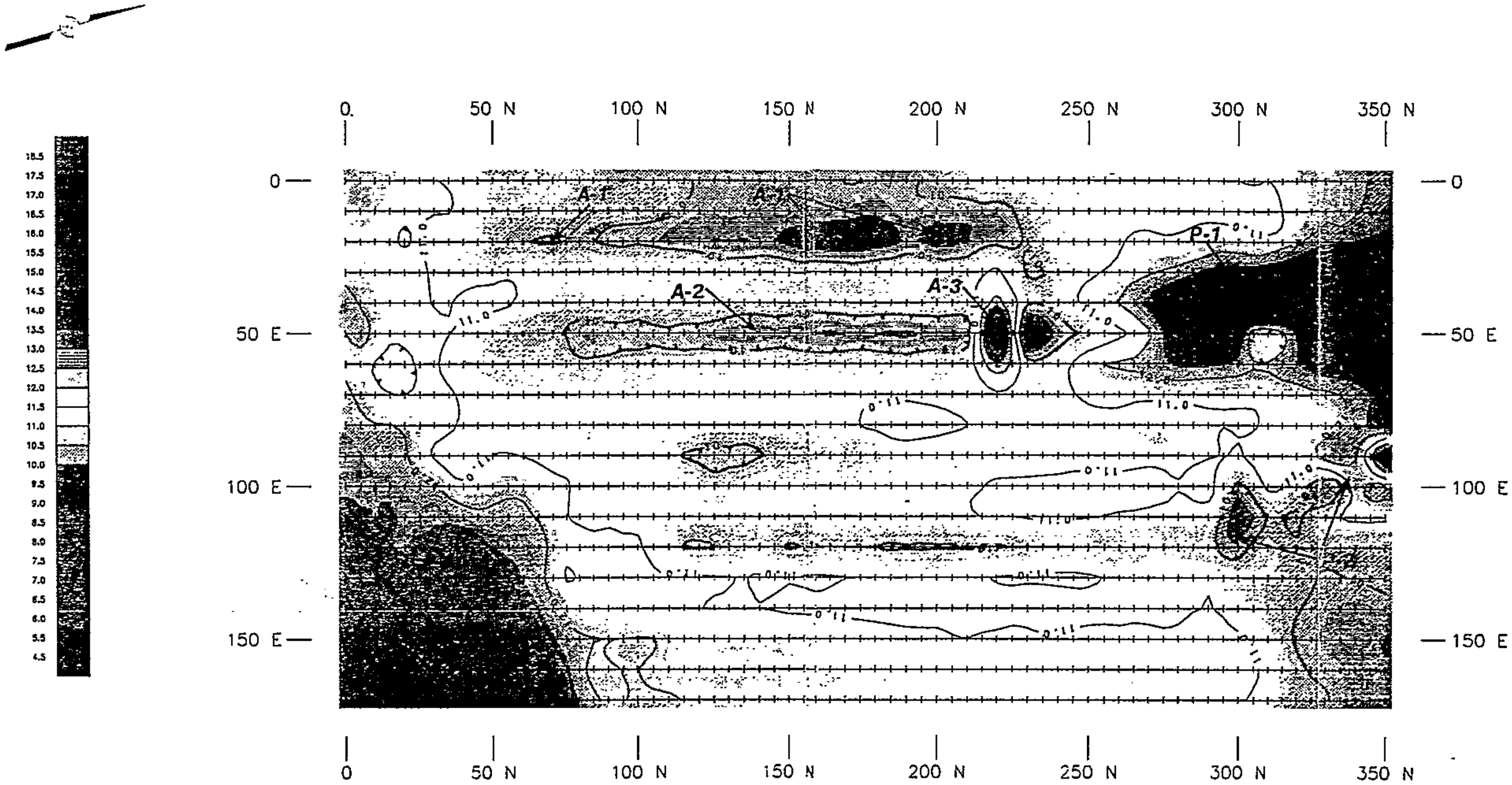

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LEGEND:

+++++++	GEONICS EM-31 SURVEY LINE
A-1	GEOPHYSICAL ANOMALY DISCUSSED IN TEXT
P-1	ANOMALY CAUSED BY BURIED PIPE

Scale 1:480

25 0 25 50 75 100

(feet)

FIGURE 4

CONTOUR MAP OF CONDUCTIVITY

S-N SURVEY LINES

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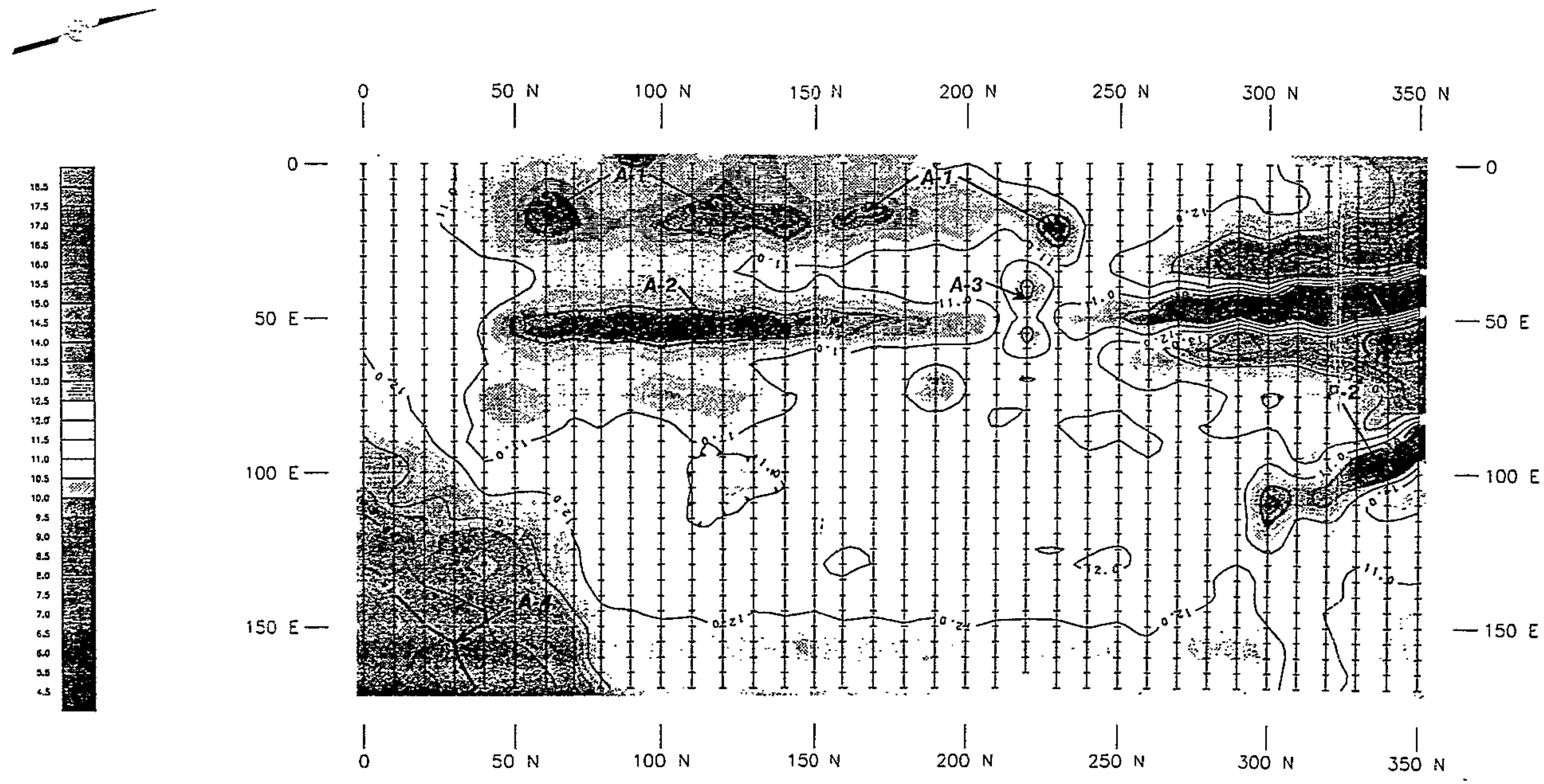

CONTOUR INTERVAL: 1 MILLISIEMEN/METER

LEGEND:

	GEONICS EM-31 SURVEY LINE
A-1	GEOPHYSICAL ANOMALY DISCUSSED IN TEXT
P-1	ANOMALY CAUSED BY BURIED PIPE

Scale 1:480

25 0 25 50 75 100

(feet)

FIGURE 5

CONTOUR MAP OF CONDUCTIVITY

W-E SURVEY LINES

WHITE BLUFFS CRIBS SITE

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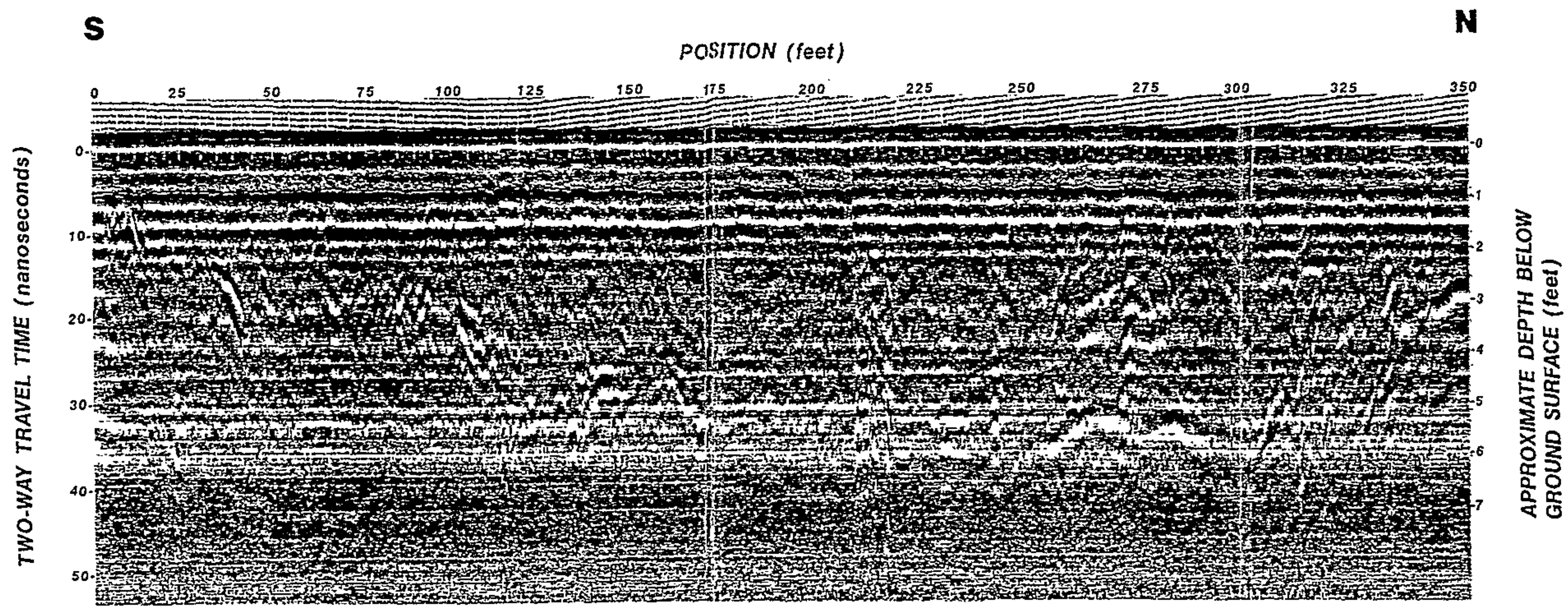

LINE GPR-10E, 500 MHz ANTENNA

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FIGURE 6

GROUND PENETRATING RADAR SURVEY
LINE GPR-10E
WHITE BLUFFS CRIBS SITE

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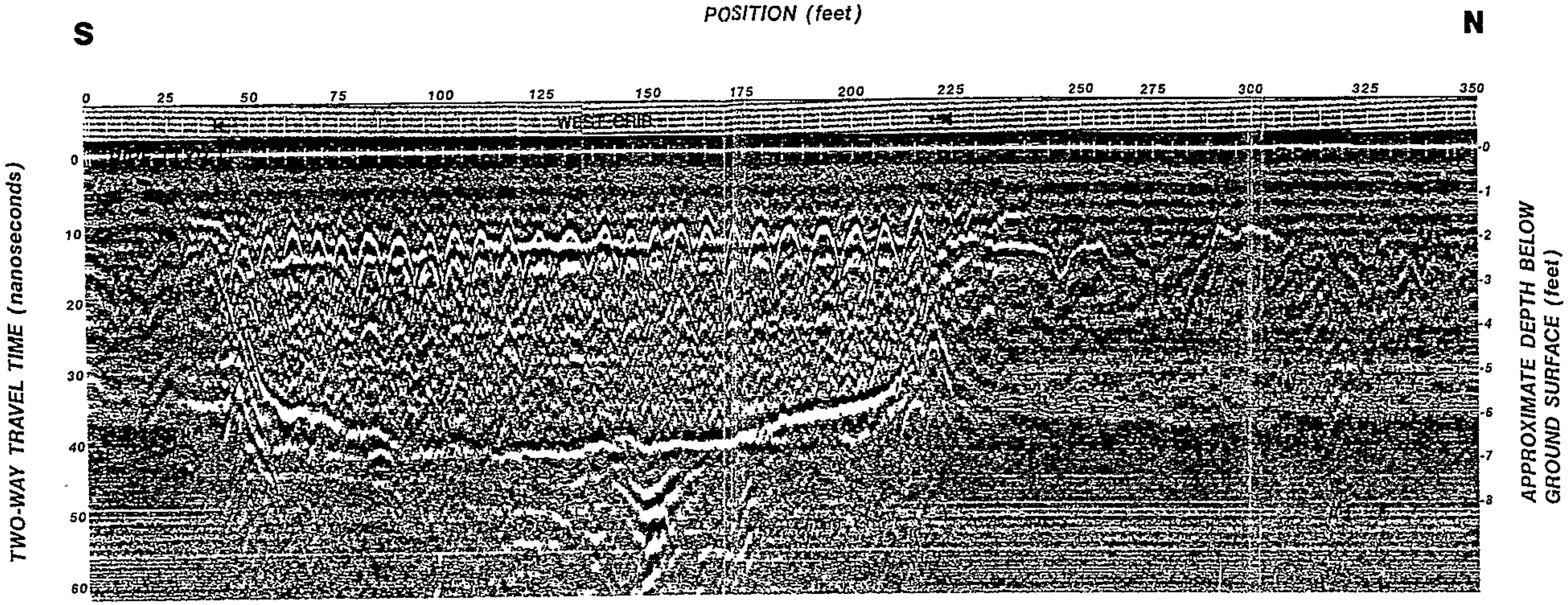

LINE GPR-50E, 500 MHz ANTENNA

FIGURE 7

GROUND PENETRATING RADAR SURVEY

LINE GPR-50E

WHITE BLUFFS CRIBS SITE

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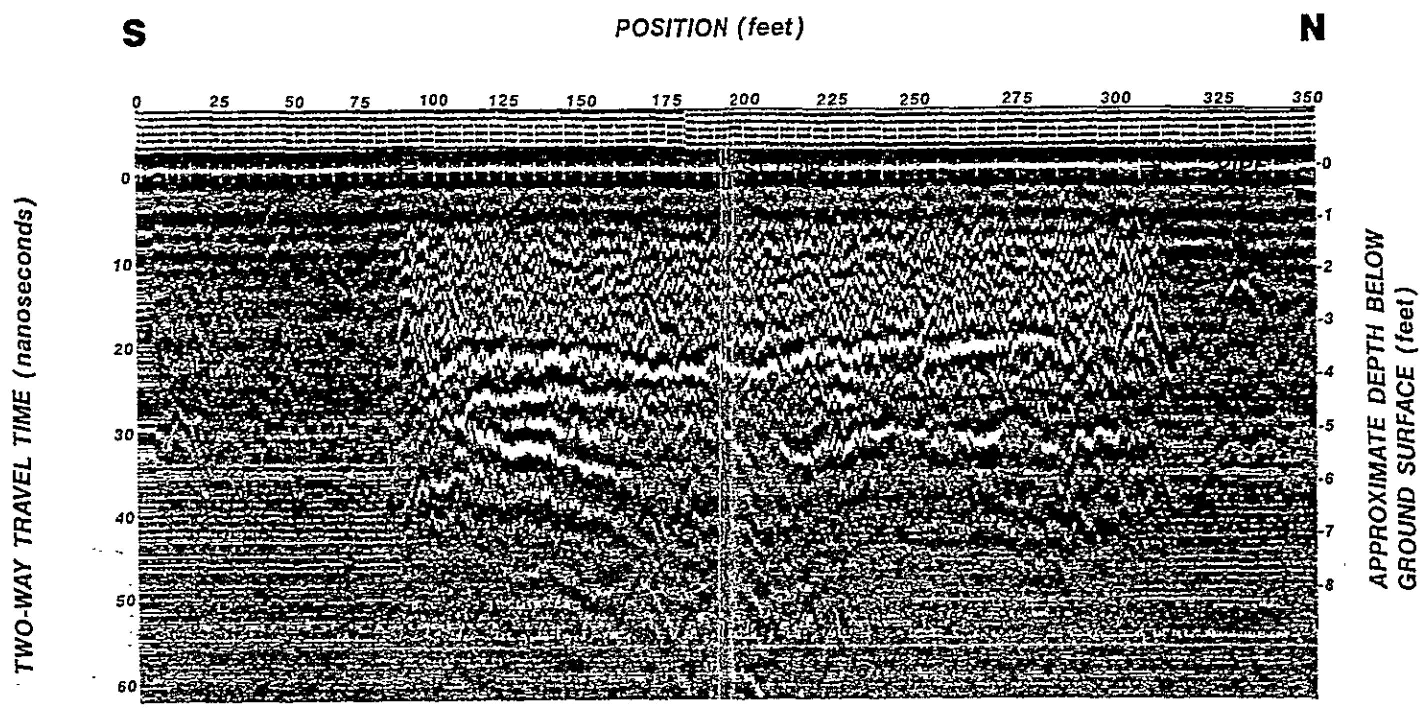

LINE GPR-100E, 500 MHz ANTENNA

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FIGURE 8

GROUND PENETRATING RADAR SURVEY

LINE GPR-100E
WHITE BLUFFS CRIBS SITE

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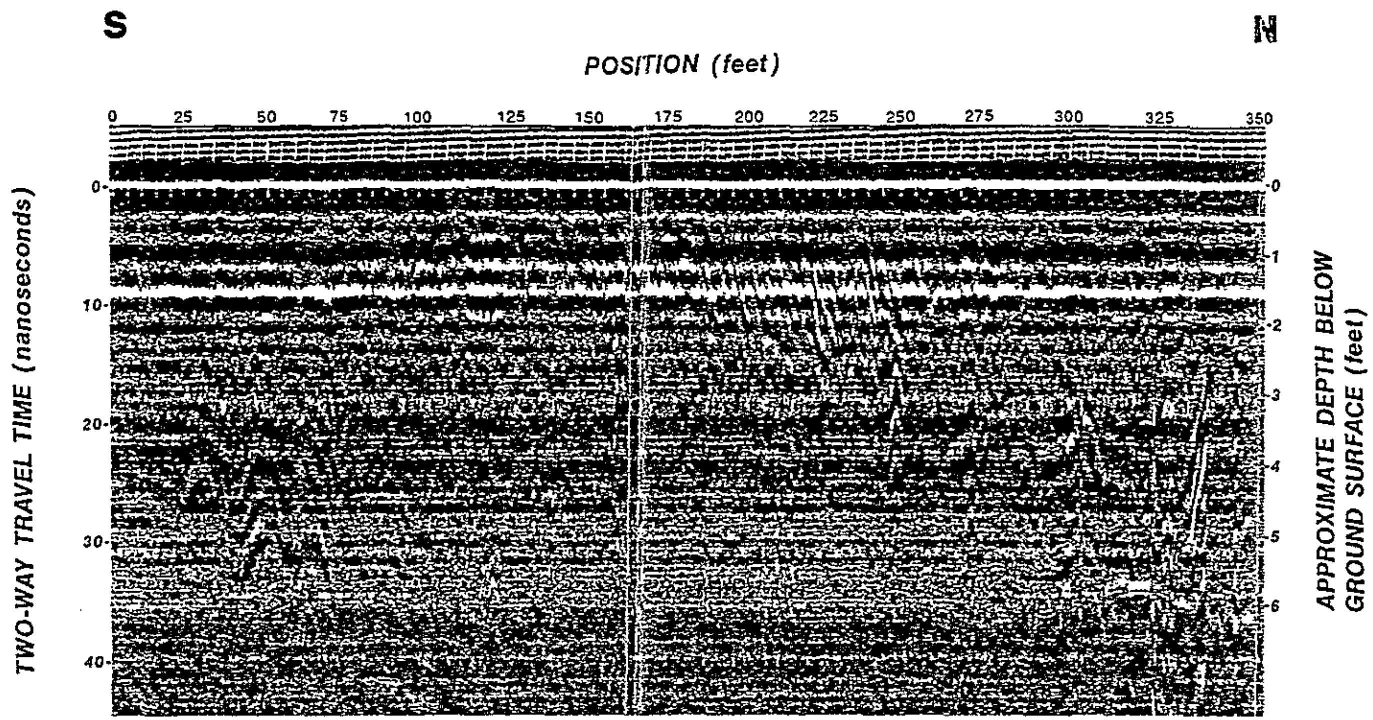

LINE GPR-150E, 500 MHz ANTENNA

FIGURE 9

GROUND PENETRATING RADAR SURVEY
LINE GPR-150E
WHITE BLUFFS CRIBS SITE

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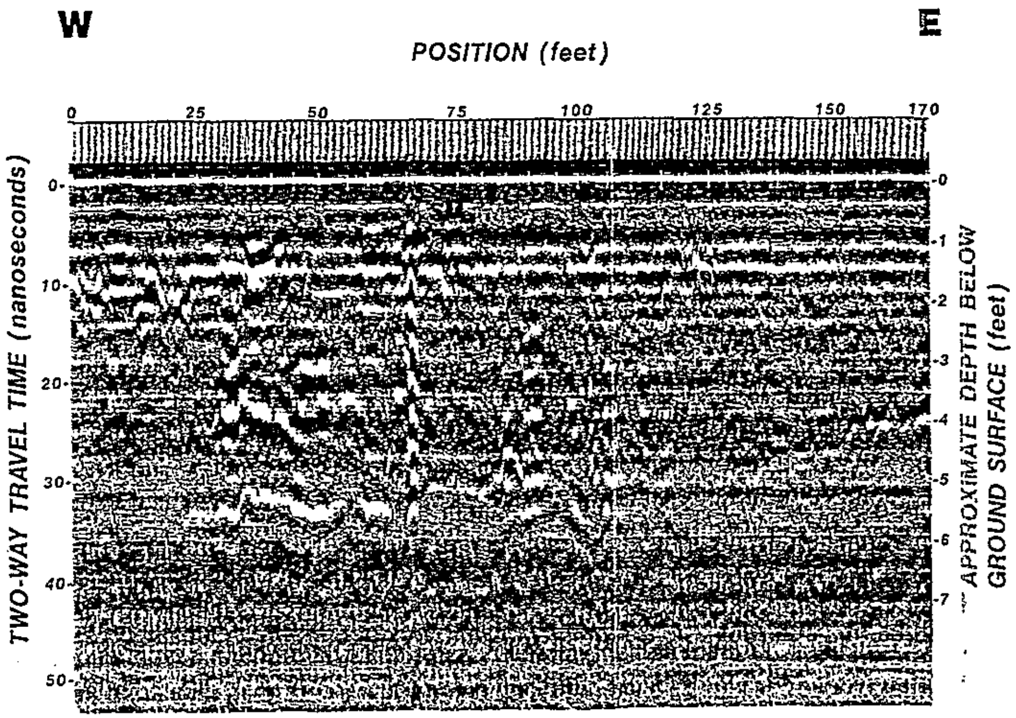
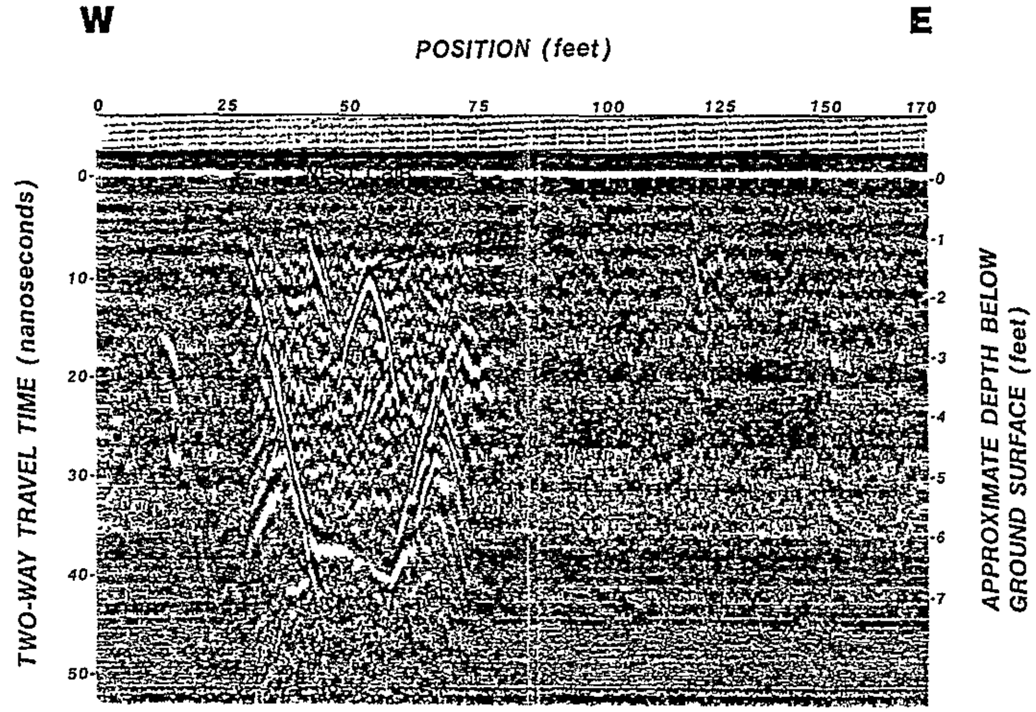


LINE GPR-20N, 500 MHz ANTENNA



LINE GPR-80N, 500 MHz ANTENNA

LEGEND:

SM ANOMALY CAUSED BY SURFACE METALLIC OBJECT

FIGURE 10

GROUND PENETRATING RADAR SURVEY

LINES GPR-20N AND GPR-80N

WHITE BLUFFS CRIBS SITE

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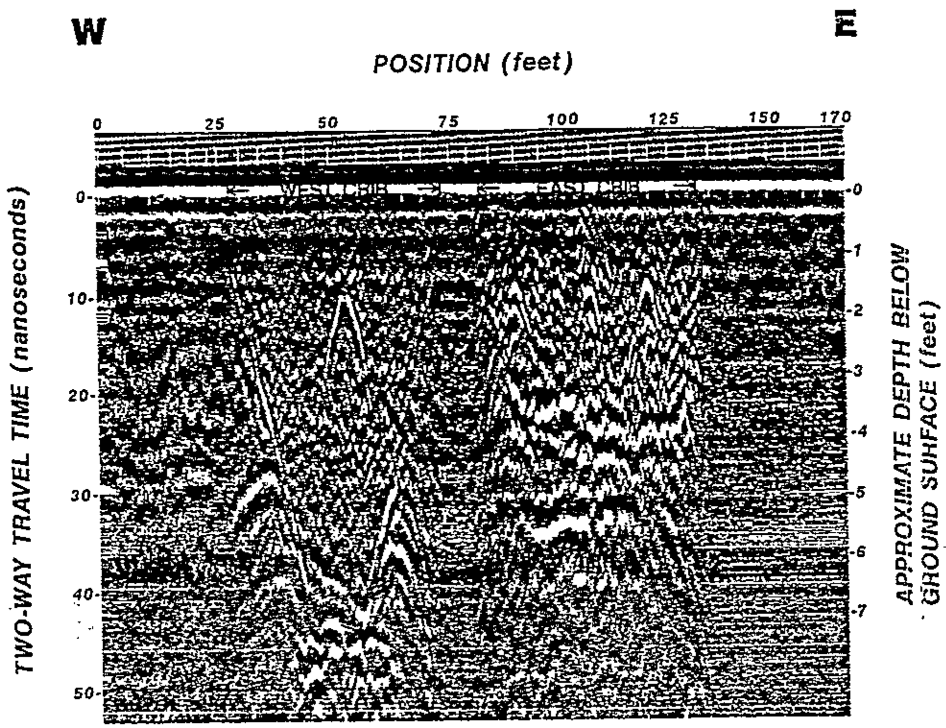
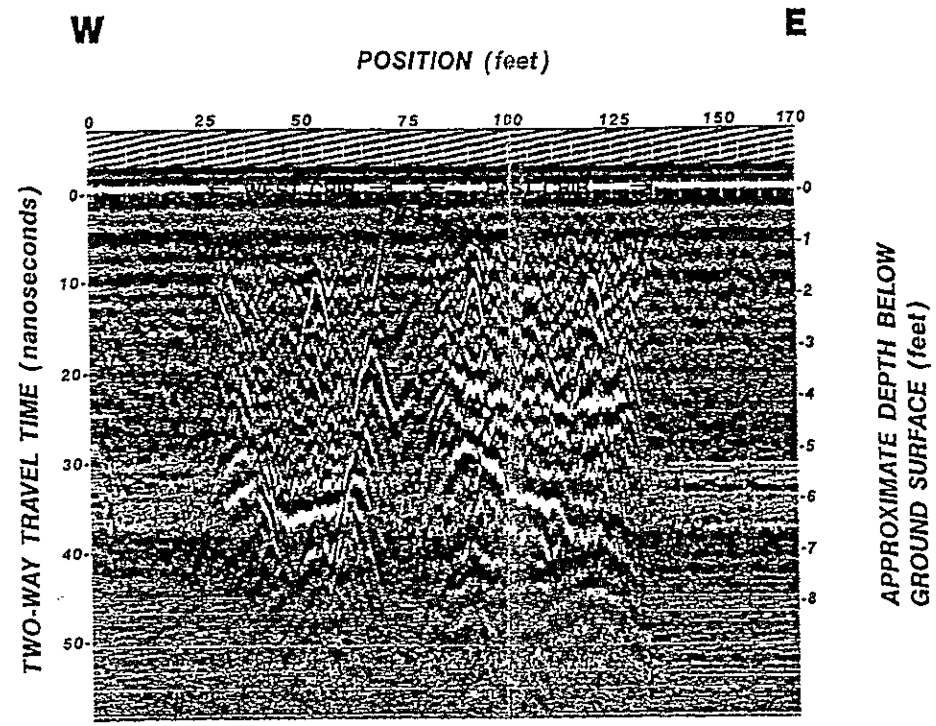


LINE GPR-140N, 500 MHz ANTENNA



LINE GPR-200N, 500 MHz ANTENNA

FIGURE 11

GROUND PENETRATING RADAR SURVEY
LINES GPR-140N AND GPR-200N
WHITE BLUFFS CRIBS SITE

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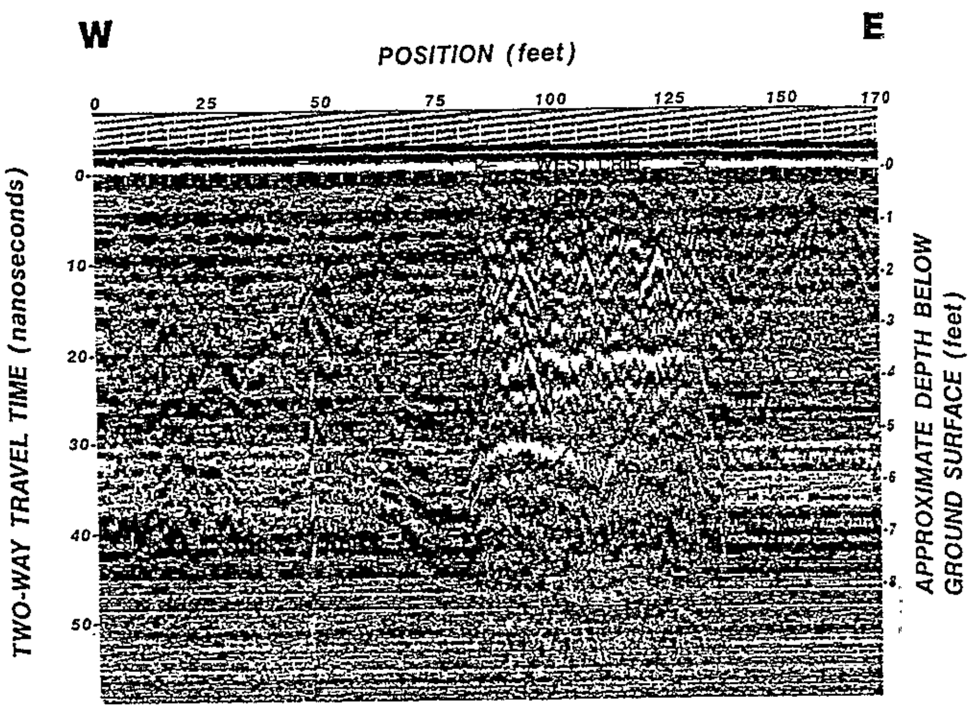
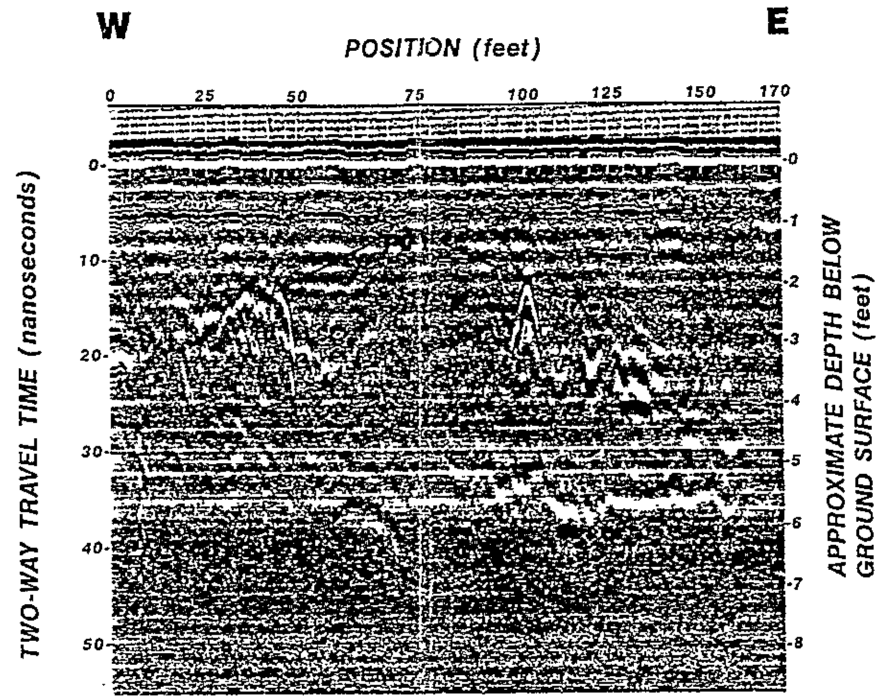


LINE GPR-260N, 500 MHz ANTENNA



LINE GPR-330N, 500 MHz ANTENNA

FIGURE 12

GROUND PENETRATING RADAR SURVEY
LINES GPR-260N AND GPR-330N
WHITE BLUFFS CRIBS SITE

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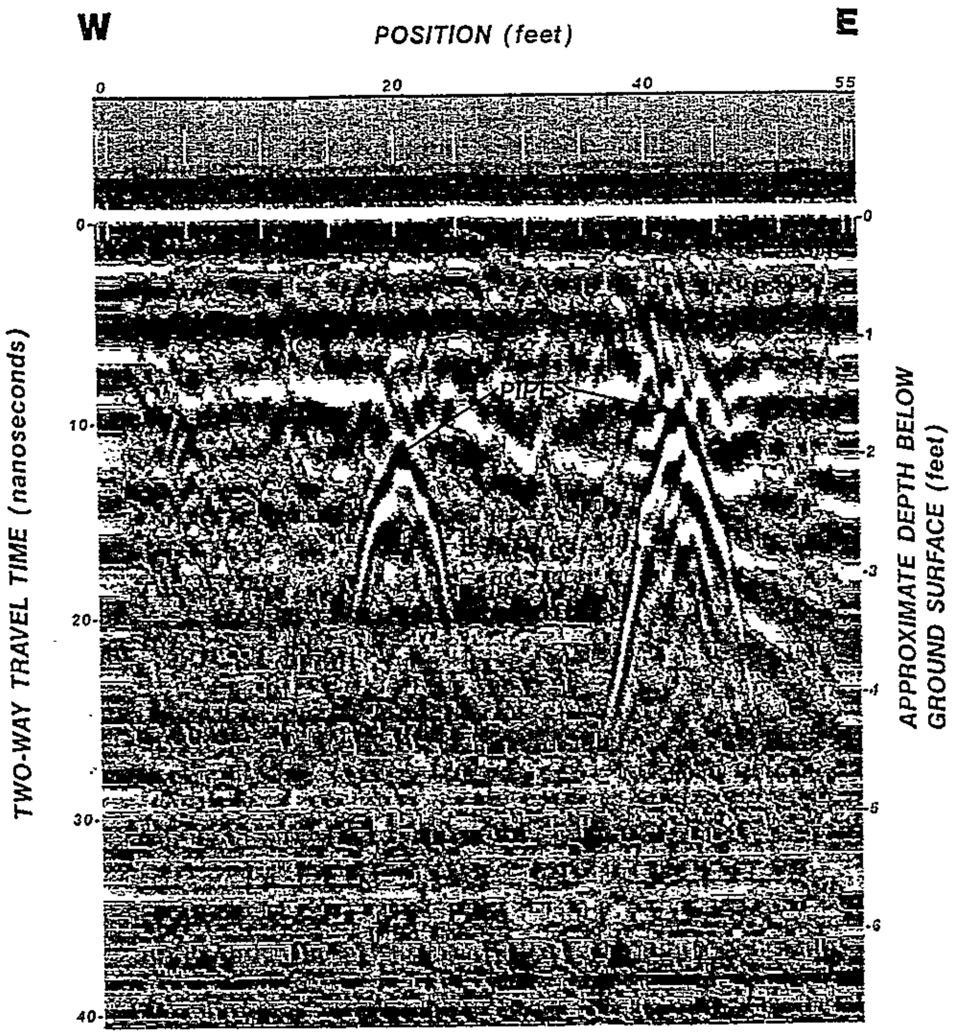
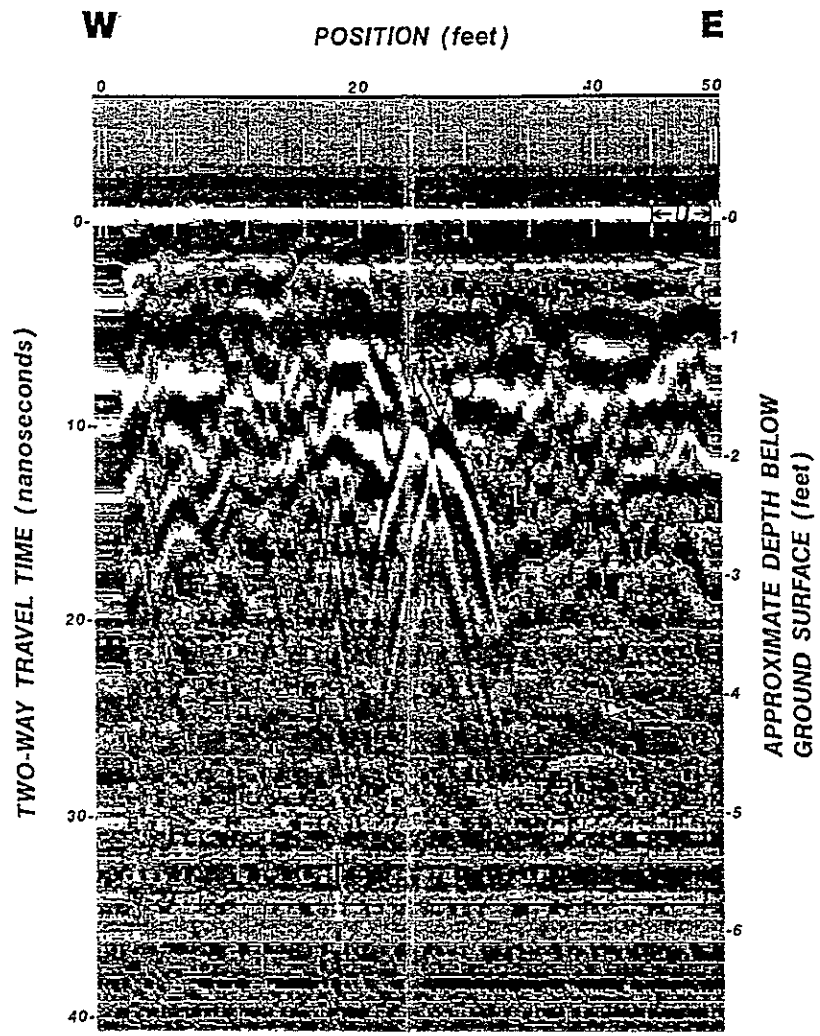


LINE GPR-405N, 500 MHz ANTENNA



LINE GPR-465N, 500 MHz ANTENNA

FIGURE 13
GROUND PENETRATING RADAR SURVEY
LINES GPR-405N AND GPR-465N
WHITE BLUFFS CRIBS SITE

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References

Benson, R. C., R. A. Glaccum and M.R. Noel, 1983. Geophysical Techniques for Sensing Buried Wastes and Waste Migration. EPA Contract No. 68-63-3050, 236 pp.

Dobrin, M.B., 1976, **Introduction to Geophysical Prospecting,** MacGraw-Hill, New York, NY.

Keller, G.V., and F.C. Frischknecht, 1966, **Electrical Methods in Geophysical Prospecting,** International Series in Electromagnetic Waves, Volume 10, Pergamon Press, Oxford, England.

McNeill, J.D., 1980, "Electromagnetic Terrain Conductivity Measurement at Low Induction Numbers," Geonics Limited, Technical Note TN-6, Ontario, Canada, October.

Milsom, J., 1989, **Field Geophysics**, Geological Society of London Handbook, Open University Press, Milton Keynes.

Telford, W.M., L.P. Geldart, R.E. Sheriff, and D.A. Keys, 1976, **Applied Geophysics,** Cambridge University Press, Cambridge, England.

Ulriksen, C.P.F., 1982: Application of Impulse Radar to Civil Engineering. Department of Engineering Geology, Lund University of Technology, Sweden.

APPENDIX A
THEORETICAL BACKGROUND

A.1 Electromagnetic Methods

Electromagnetic induction equipment used during this investigation consists of a Metrotech Model 810 pipe/utility locator (Metrotech) and a Geonics EM-31DL terrain conductivity meter (EM-31) with an Omni digital data logger.

A.1.1. Utility Locator Methods

The Metrotech line tracer is specifically designed to accurately locate and delineate underground pipes and utilities. A transmitter emits a radio-frequency signal that induces a secondary EM field in nearby utilities. A receiver unit measures the signal strength of this secondary field and emits an audible response to allow the precise location and tracing of the pipe, cable, or other conductor in which the signal is induced. If the utility is accessible, the source signal can be directly applied to it, making the secondary field much larger and more readily measured. The line tracer is effective in locating long metallic objects.

A.1.2 Electromagnetic Induction Methods

The EM-31 has a transmitter coil mounted at one end and a receiver coil at the other end of a 12-foot-long plastic boom. An audio frequency alternating current is applied to the transmitter coil, causing the coil to radiate a primary EM field. As described by Faraday's law of induction, this time-varying magnetic field induces eddy currents in conductive materials in the subsurface. These eddy currents have an associated secondary magnetic field with a strength and phase shift (relative to the primary field) that are dependent on the conductivity of the medium. The receiver coil measures the resultant effect of both primary and secondary fields. By comparing the signal at the receiver to that at the transmitter, the instrument records the component of the secondary field in-phase (in-phase) and 90 degrees out-of-phase (quadrature) with the primary field.

Most geologic materials are poor conductors. The flow of current through the material takes place in the pore fluids (Keller and Frischknecht, 1966); as such, conductivity is predominantly a function of soil type, porosity, permeability, pore fluid ion content, and degree of saturation. The EM-31 is calibrated so that the out-of-phase component is converted to electrical conductivity in units of millisiemens per meter (mS/m) (McNeill, 1980). The in-phase component is read in parts per thousand (ppt) of the primary EM field and is generally adjusted in the field to read zero response over background materials.

The depth of penetration for EM induction instruments is dependent on the transmitter/receiver separation and coil orientation (McNeill, 1980). The EM-31 has an effective exploration depth of about 18 feet when operating in the vertical dipole mode (horizontal coils). In this mode, the maximum instrument response results from materials at a depth about two-fifths the coil spacing (about 2 feet below ground surface with the instrument at the normal operating height of about 3 feet), providing that no large metallic features such as tanks, drums, pipes, and reinforced concrete are present. A single buried drum typically can be located to depths of about 5 feet, whereas clusters of drums can be located to significantly greater depths if background noise is limited or negligible. The EM-31 has an effective exploration depth of about 9 feet when operating in the horizontal dipole mode (vertical coils) and is most sensitive to materials immediately beneath the ground surface.

The EM-31 generally must pass over or very near to a buried metallic object to detect it. Both the out-of-phase and in-phase components exhibit a characteristic anomaly over near-surface metallic conductors. This anomaly consists of a narrow zone having strong negative amplitude centered over the target and a broader lobe of weaker, positive amplitude on either side of the target. For long, linear conductors such as pipelines, the characteristic anomaly is as described when the axis of the coil (instrument boom) is at an angle to the conductor. However, when the instrument boom is oriented parallel to the conductor, a positive amplitude anomaly is obtained.

EM applications include mapping conductive groundwater contaminant plumes in very shallow aquifers and delineating oil brine pits; landfill boundaries; buried pipes, cables, drums, tanks; and pits and trenches containing buried metallic and nonmetallic debris.

A.1.3 Ground Penetrating Radar Methods

Ground penetrating radar (GPR) equipment used during this investigation consisted of a Geophysical Survey System, Inc. (GSSI) System 10 equipped with a 500-MHz monostatic antenna.

When conducting a GPR survey, the antenna containing both a transmitter and a receiver is pulled along the ground surface. The transmitter radiates short pulses of high frequency (center frequencies in the range of 80-900 MHz) EM energy into the ground. This EM wave propagates into the subsurface at a velocity dependent upon the relative dielectric constant of the medium through which the wave travels. When the wave encounters the interface of two materials having different propagation velocities or some other electrical heterogeneity, a portion of the energy is reflected back to the surface. The contrast in velocity between the two media can be quantified by a reflection coefficient at the media interface. The magnitude of the reflection coefficient increases as the contrast in velocities increases, and the coefficient sign is positive or negative depending on whether the velocity increases or decreases, respectively, at the interface. The reflected signal is detected at a receiver antenna and often as a characteristic triplet that is the result of the receiving antenna response and of multiples generated along the propagation path. The signal is transmitted to a control unit, displayed on a color monitor, and saved on digital tape.

As predicted by Maxwell's equations for a propagating EM wave, two kinds of charge flow are caused by the associated alternating electric and magnetic fields (Ulriksen, 1982). The charge flows are conduction and displacement currents. The conduction current term is predominant at lower frequencies, and conduction currents are used in the EM induction method. At the higher frequencies used in the GPR method, the displacement current term becomes predominant, because the high frequencies will set bound charges in motion, causing polarization.

The physical properties that describe the movement of charges by conduction and displacement currents are the conductivity and the dielectric constant of the medium, respectively. Conductivity is a measure of the ease with which charges and charged particles move freely through the medium when subjected to an external electric field. The dielectric constant, or its value normalized by the dielectric constant of free space called the relative dielectric constant, is a measure of how easily a medium polarizes to accommodate the EM fields of a propagating wave (Keller and Frischknecht, 1966).

Although conductivity has a smaller effect on the transmission of EM waves emitted from a GPR unit, it has an important effect on the attenuation of the waves (Ulriksen, 1982). Highly conductive media will attenuate the EM signal rapidly and restrict depth penetration to the first several feet. Highly resistive (poorly conductive) media allow deeper penetration. The frequency of the transmitted waves also affects the depth of penetration. Lower frequencies penetrate deeper but have lower resolution, whereas higher frequencies can resolve smaller objects and soil layers at the expense of depth penetration. At many sites in California, soils are relatively conductive and depth penetration is often limited to about 5 feet.

In unconsolidated materials, conduction occurs predominantly through pore fluids (Keller and Frischknecht, 1966). Therefore, changes in pore fluid content, porosity, permeability, and degree of saturation will, affect reflected and refracted EM signals. Backfilled trenches, in which there may be different compaction densities relative to the surrounding area, can be identified in this manner. When the target of a GPR survey is a metallic conductor such as metal pipes and cables, drums, tanks, or ammunition shells, the characteristic response is somewhat different because an EM wave is completely reflected upon reaching the metallic conductor. Thus, the property of total reflection makes metallic targets well suited for detection within the range of the GPR unit. No reflections will occur from below the metallic conductor, although multiples are common. The edges of the metallic reflector will exhibit diffraction patterns as a result of the transmitting and the receiving antennae being unfocused but emitting and receiving from a 45-degree cone. The cone allows the radar to detect objects that are ahead of it, placing them deeper in time. As the radar approaches the object, the reflection becomes shallower, with the shallowest reflection taking place when the radar is immediately above the object. An identical pattern occurs as the antenna moves away from the object.

GPR applications include delineation of pits and trenches containing metallic and nonmetallic debris; location of buried pipes, drums, and tanks; and mapping of landfill boundaries and near-surface geology. Near-surface metallic objects such as pipes and tanks exhibit a characteristic high-amplitude hyperbolic anomaly and generally are relatively easy to recognize.

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